① Avg. distance between Earth and Moon $= 384{,}000$ km

(a) $t = \dfrac{2d}{c} = \dfrac{2(384{,}000\ \text{km})}{3\times10^{5}\ \text{km/s}} = 2.56\,\text{s}$

(b) An additional 4 cm in the round-trip distance would increase the travel time by

$$t = \frac{0.04\,\text{m}}{3\times10^{8}\ \text{m/s}} = 1.3\times10^{-10}\,\text{s}$$

② $f = \dfrac{c}{\lambda} = \dfrac{2.99792\times10^{8}\ \text{m/s}}{632.82\times10^{-9}\,\text{m}} = 4.73740\times10^{14}\,\text{Hz}$

$$f = \frac{c}{\lambda} \Rightarrow df = -\frac{c}{\lambda^2}\,d\lambda \Rightarrow \Delta f = \frac{c}{\lambda^2}\,\Delta\lambda$$

$$\Delta f = \frac{3\times10^{8}\ \text{m/s}}{(632.82\times10^{-9}\,\text{m})^2}(0.01\times10^{-9}\,\text{m}) = 7.5\times10^{9}\,\text{Hz}$$

③ In vacuum: $t_v = \dfrac{D}{c}$ $\qquad D = 1.61$ km

In air: $t_a = \dfrac{D}{v_a} = \dfrac{D}{c}\,n_a$ $\qquad n_a = 1.00029$

$$t_a - t_v = \frac{D}{c}(n_a - 1) = \frac{1.61\ \text{km}}{3\times10^{5}\ \text{km/s}}(.00029)$$

$$= 1.56\times10^{-9}\,\text{s}$$